MASSACHUSETTS FARM

Energy Best Management Practices for

Orchards & Vegetable Farms

Massachusetts Farm Energy Program

Conservation • Efficiency • Renewables

MASSACHUSETTS FARM

Energy Best Management Practices

Berkshire-Pioneer Resource Conservation & Development Area

GDS Associates

Massachusetts Department of Agricultural Resources

Massachusetts Farm Energy Program

USDA Natural Resources Conservation Service

Amherst, Massachusetts · 2010

MASSACHUSETTS FARM ENERGY GUIDES BY FARM SECTOR

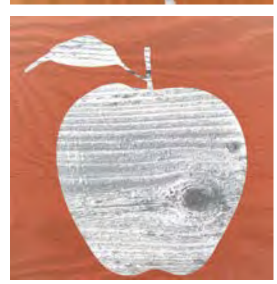
Please note that this guide is part of a series of farm energy Best Management Practice guides available for the following sectors and topic areas:

Dairy Farms

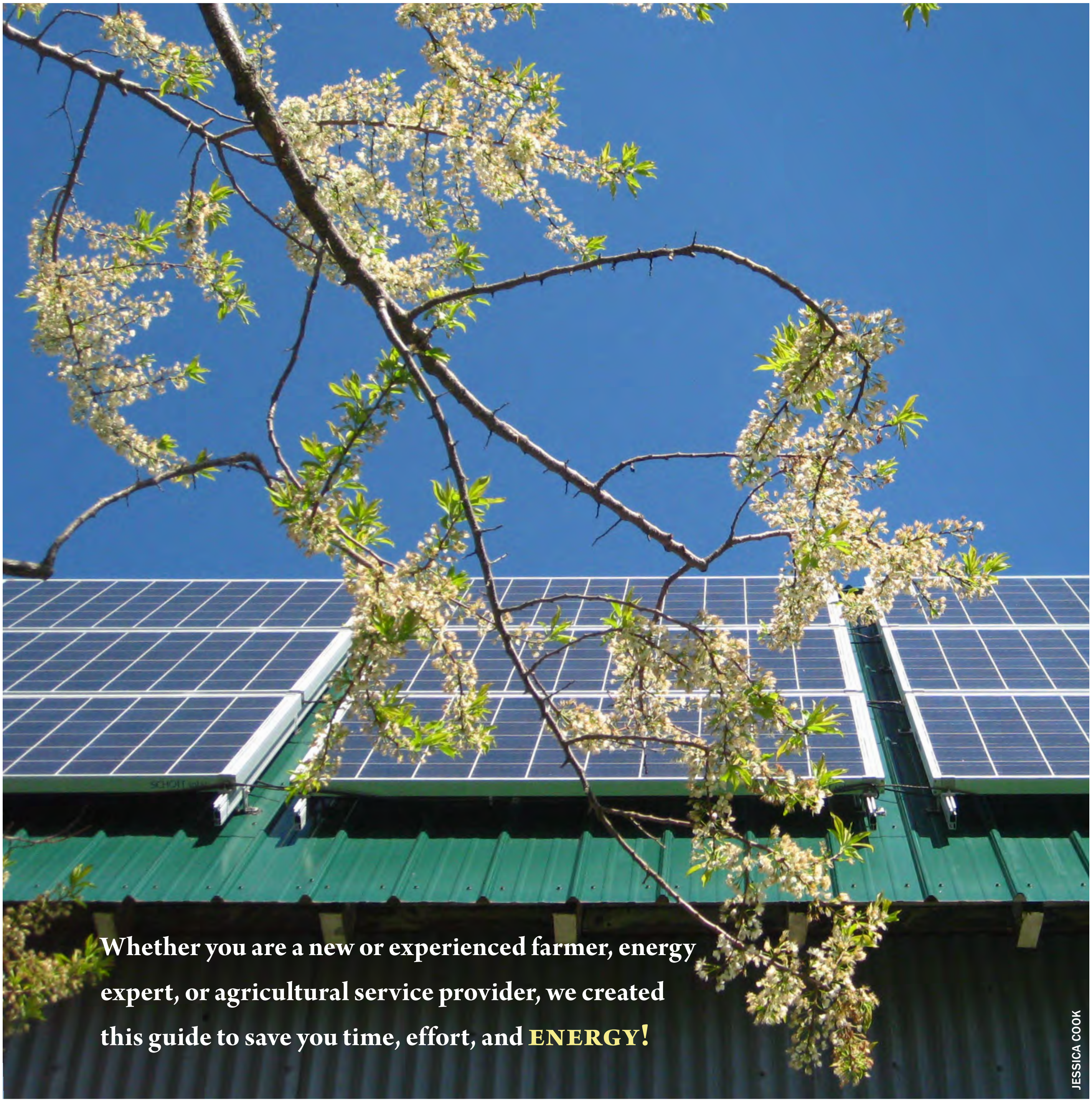
Greenhouses

Maple Sugaring

Orchards & Vegetable Farms



Renewable Energy



JESSICA COOK

Welcome to the Massachusetts Farm Energy Best Management Practices Guide

Practical solutions & entry points

This guide is about practical steps you can take immediately, with a focus on the most common and cost-effective equipment upgades and systems currently available for farms in our region.

For farmers who are managing a constant flow of weather events and day-to-day business needs, we offer an entry point to on-farm energy savings and renewable systems that make use of the technical skills and systems-thinking of our local community.

Thinking of systems from the start

The farm energy guide is organized by sector, focusing on retrofits that work for existing farming operations. However, farmers can also apply the guidance provided in these pages to incorporate energy issues into the planning and initial design stages of new agricultural businesses.

There is an increasing amount of interest in energy amongst the state's farmers, and examples in this guide can provide a launchpad for more innovative energy systems in the future.

The goals of these energy best management practices are to:

Strengthen farm businesses by lowering operating costs, reducing labor, and increasing profits over time.

Reduce environmental impacts of the agricultural sector, with a focus on lowering carbon emissions.

Help farms transition into the next generation by utilizing efficient technology and forward-thinking design.


JESSICA COOK

Sometimes you just need a place to start— —based on good information and solid economics.

We hope that by breaking things down by process or technology—looking at average savings and commonly recommended measures—we offer readers a place to start their projects.

We know for many farms economic feasibility is the first question when it comes to on-farm energy projects—is the investment worthwhile?

We have highlighted estimated payback periods in the following pages, identifying the number of years an upgrade will take to pay for itself.

While we calculate the dollar savings in fossil fuels or other energy sources, it's important for you to consider other benefits on the farm, such as reduced farm labor or increased sales resulting from greener systems.

The examples in this guide are drawn from real life, based on averages across farms in Massachusetts who have worked with MFEP, so payback numbers are directly applicable to the scale of farms in our region.

Encouraging climate and resources

Forward-thinking energy policies at the state level have combined with supportive agencies and utility programs, financial incentives, and good partners to provide fertile ground for farm energy projects in Massachusetts.

We are enthusiastic about the energy future of the agricultural community in our region, and acknowledge the motivated farmers who are open to sharing their experiences, willing auditors, and proactive installers who are getting projects up and running.

We encourage you to take advantage of these key resources to move ahead with your own farm energy project!

— the Massachusetts Farm Energy Program team

Acknowledgements

This farm energy best management practices guide was compiled and written by GDS Associates, Inc. (GDS) for the Massachusetts Farm Energy Program (MFEP). Specifications and recommendations in this document are based on industry-specific research and informed by the audits and projects implemented with the assistance of the Massachusetts Farm Energy Program (MFEP) between 2008 and 2010.

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Introduction

The *Massachusetts Farm Energy Best Management Practices Guide* provides the Commonwealth's agricultural community with resources and methods to reduce energy use and produce renewable energy on farms. These recommended on-farm energy upgrades improve farm viability and minimize the environmental impact of the agricultural industry in Massachusetts by reducing energy consumption, operating costs, emissions, and dependence on fossil fuels.

These guides focus on conventional energy best management practices (BMPs) - cost-effective practices that offer significant environmental and economic benefits - for the four primary agricultural sectors represented in the Commonwealth: greenhouses, dairy farms, orchards and vegetable farms, and maple sugaring. It also covers considerations for on-farm renewable energy options, including wind, solar thermal, solar photovoltaic and biomass.

This document aims to be a practical resource for farmers and service providers alike, organized to help readers understand farm energy use, evaluate potential equipment upgrades, and prioritize energy efficiency and renewable energy opportunities. The information in this guide can also be used to inform policy, technical assistance programs, and government agency and public utility cost-share programs for energy efficiency and renewable energy on farms.

The information in this guide is based on industry-specific research and Massachusetts Farm Energy Program (MFEP) data from more than fifty energy projects implemented between 2008 and 2010. For areas not covered in this document, additional information can be found by contacting the Massachusetts Farm Energy Program (MFEP).

Environmental Impact of Energy Use

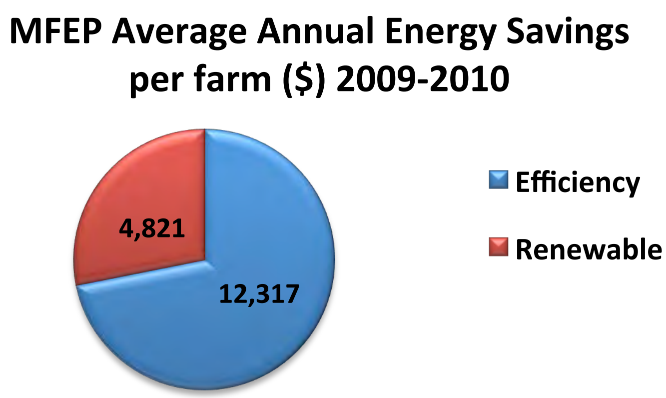
Energy conservation and renewable energy systems on farms can help reduce the use of fossil fuels and related greenhouse gas emissions, and mitigate the contribution of Massachusetts agriculture to point-source pollution and global climate change. Massachusetts' farmers can set an example for other industries in the region by making viable business decisions that improve operations and profitability while reducing negative environmental impacts of "business as usual". MFEP's experience illustrates farms' improved environmental performance - through reduced carbon dioxide emissions – as a result of energy efficiency and renewable projects.

Economic Benefits of Energy Savings

New England farmers pay 23-56% higher rates for energy resources than the U.S. average. As farmers identify the source of their energy demand and make improvements to their systems, they can reduce their dependence on fossil fuels and improve their bottom line. MFEP's work with has assisted farmers do exactly that, thus having a direct impact on the financial viability of many Massachusetts farms.

The average net income of a Massachusetts farmer is just over $12,000 according to the National Agricultural Statistics Service. At the same time, average annual energy savings from farm energy efficiency projects facilitated through MFEP average out at $12,000 per farm (see chart below), thus making energy efficiency improvements a sound business decision that can have a significant impact on overall farm viability. The economic benefit of these savings is further multiplied as farmers reinvest in the local economy in a variety of ways as they maintain and build their businesses.

It is important to note that energy projects results in different rates of financial returns for farms, either through reduced energy use or offsetting fossil fuel use with renewable energy. Renewable projects can work out favorably in terms of overall return on investment for farms, particularly with the support of grant and payment programs. However, efficiency projects save 2.5 times more energy on average than renewable systems generate per dollar invested.



About the Massachusetts Farm Energy Program

What is the Massachusetts Farm Energy Program?

The Massachusetts Farm Energy Program (MFEP) is a full-service program for technical and financial assistance for farmers and agricultural businesses. It is a statewide collaborative effort, bringing together federal, state, industry, and private support to streamline resources available to Massachusetts farmers in order to 1) increase on-farm energy conservation and efficiency, 2) promote alternative and renewable energy strategies for on-farm energy generation, 3) improve farm viability by reducing energy consumption and costs, and 4) reduce agricultural greenhouse gas emissions. MFEP is a joint project between the following partners:

- Massachusetts Department of Agricultural Resources (MDAR) www.mass.gov/agr
- USDA – Natural Resources Conservation Service (NRCS) www.ma.nrcs.usda.gov
- Berkshire-Pioneer Resource Conservation & Development Area (BPRC&D) www.berkshirepioneerrcd.org

MFEP has offered a range of services to the farming community, including technical assistance, audits and consultations, financial incentives, and facilitation to leverage funds to bring projects from initial concept to implementation.

Why MFEP?

Electricity and fossil fuel costs have increased by approximately 30% in the last few years. The impact on farms has meant a dramatic increase in costs related to power, refrigeration, heating, ventilation, lighting, transportation, fertilizer, and feed. Rising energy costs reduce profit margins for all farmers and directly threaten the viability of farms across the Commonwealth.

The agricultural community has not maximized energy savings in part due to challenges in navigating an ever-changing landscape of support programs. MFEP streamlines these resources and provides direct technical assistance through energy audits, renewable energy assessments, and incentives for implementation of audit recommendations, including those recommended by public utility programs. As a result of complex partnerships between farm business owners, government agencies, for-profit practitioners, and public programs – farm energy upgrades are contributing to the region's environmental goals and stability and resilience of our agricultural communities.

Best Management Practices for Orchards and Vegetable Farms

In this section you will find the following best practices:

- High efficiency refrigeration and heat recovery
- Lighting for farm stands, packing houses, and storage areas

Orchards and vegetables are an important part of the makeup of Massachusetts agriculture, with an annual commodity worth of $59,000,000 for vegetables, melons, potatoes, and sweet potatoes, and $100,623,000 for fruits, tree nuts, and berries according to 2007 census data.

The first step in proper energy management is to learn about best practices. This handbook will help you consider which energy efficiency upgrades are applicable to your farm.

The second step is to consider an energy audit. An energy audit can help determine which energy efficiency measures, based on the existing conditions and equipment of your facility will be most useful. The audit will point out the major energy users and ways to save money through energy conservation and efficiency.

For orchards, and fruit and vegetable farms, refrigeration and lighting are major sources of energy use, along with other miscellaneous equipment. Refrigeration typically uses the most energy and should be the highest priority, followed by lighting upgrades.

Refrigeration: There are low-to-no-cost ways to save energy such as regularly cleaning evaporator and condenser coils and having an annual tune-up for refrigeration systems. Accumulated dirt and dust on coils can result in a reduction of heat transfer, lowering the efficiency of the equipment.

By following the recommendations in the *High Efficiency Refrigeration* section, it is possible to cut electricity usage by 35% or more by replacing old refrigeration units. Due to the wide range of refrigeration systems, recommendations may not be applicable for all systems. An energy audit is highly recommended for refrigeration systems, especially older systems and seasonal operations, to determine potential savings and applicability.

Lighting: Easy energy savings can be achieved by changing out any old screw-in incandescent bulbs with compact fluorescent lamps (CFLs). Motion sensors or photosensors can be an inexpensive way to conserve energy by preventing lights being on when not in use. Also consider retrofitting or replacing T12 light fixtures with HPT8 lamps and electronic ballasts. Payback for lighting is highly dependent on annual hours of use, so first priority should be to replace old fixtures that are used the most. There are many different types of lighting options for different types of facilities and ceiling heights. An energy audit can help determine the payback and what type of lighting is appropriate.

Best Practice

High Efficiency Refrigeration Including Heat Recovery

Source: http://www.extension.org[1]

At a Glance:

- Energy efficient refrigeration can save 20% - 35% on energy costs
- High efficiency refrigeration improvements and/or heat recovery often have a short payback

Description of Best Practice

Refrigeration is used on orchards and vegetable farms to slow the metabolism and preserve the quality of perishable horticultural products. Storage requirements for different types of fruits and vegetables vary and it is important to understand the specific storage needs of the products being stored. Generally, cold storage is grouped into one of two categories:

> ***Refrigerated Storage:*** The internal temperature is regulated using mechanical refrigeration (can be supplemented with outside air), and humidity levels may or may not be controlled. There is no specific control over oxygen, nitrogen or carbon dioxide levels.

***Controlled Atmosphere (CA)*:** CA is a type of old storage in which oxygen, carbon dioxide, and nitrogen concentrations are regulated, in addition to temperature and humidity. In Massachusetts, CA storage is often used for the storage of apples.

Cold storage on orchards and vegetable farms is often sized to meet the large demand periods of loading during harvest season. Once field heat has been removed, refrigeration capacity can be reduced by as much as 80% to 90%. As an example, a storage system may require 16 tons of cooling capacity just to meet the loading period that occurs over 8 days, yet use less than 3 tons cooling capacity throughout the rest of the storage season.[2] In this case, installation of a 3-ton system will not allow rapid field heat removal and risks product spoilage.

Components of High Efficiency Refrigeration:

- *Energy Efficient Lighting*. T-8 fluorescent lighting has proven to use about 75% less energy than incandescent lighting.
- *Energy Efficient Compressors*. Scroll compressors, linear compressors, and the addition of electronic expansion valves are all ways to achieve better refrigeration compressor energy efficiency when compared to older reciprocating compressors. Variable speed refrigeration systems are available which accommodate the variable demand which occurs between loading and storage seasons.
- *Floating Head Pressure*. Allowing the head pressure of the compressor to float at lower ambient temperatures will decrease the load on the compressor.

Best Practices – High Efficiency Refrigeration

Best Practice

- *High Efficiency Fan Motors*. Removing heat from the compressor system has become more efficient with use of electronically-commutated motors (ECM), and improved fan design.
- *Insulation and Heat Loss Design*. Adding gaskets to doors and openings, thick wall and ceiling insulation, and foam-in place rather than fiber insulation improve energy efficiency.
- *Improved Defrost Methods*. Heat recovery from refrigerant gas may be used in modern defrost methods to melt freezer frost as well as to evaporate condensate from refrigeration defrost. Defrost controls have replaced standard timers, and operate according to the temperature of the unit allowing for complete defrost only when needed.
- *Heat Recovery Condensation Control*. Rather than electric resistance heat, heat recovery from refrigerant gas can be used under the surface of door openings and around the door seal to prevent sweating.
- *Improved condensate drains*. These drains prevent infiltration heat loss
- *Heat Recovery for Space or Water Heating*. Utilize heat from refrigeration compressors to pre-heat water and/or provide space heating.
- *Outside Air Economizers*. During the winter months, outside air economizers can be used for cooling in lieu of mechanical refrigeration systems.

Description of Best Practice

Energy efficiency may be gained through a variable-load cooling system with high efficiency compressors which run according to cooling demand. Efficiency gains are also possible through installing and maintaining insulation levels of at least R-25 for walls and R-30 for ceilings.[3]

Not all models are easy or cost-effective to retrofit with the recommended efficiency upgrades. Consider the life expectancy of the refrigeration system and weigh retrofit costs against the cost of purchasing a new energy efficient model. An energy audit can help you with this decision process.

Using heat recovery from refrigeration compressors for water heating makes the most sense in applications where there is hot water or space heating demand throughout the year.

It is recommended to consider the cost-to-operate when making a purchase decision. The operating cost of refrigeration is often greater than the up-front cost of the purchase. So, if a standard model has a lower initial cost than a high efficiency model, the standard models operating cost will likely be much higher, resulting in a much higher life cost over the life of the refrigerator unit.

Best Practices – High Efficiency Refrigeration

Best Practice

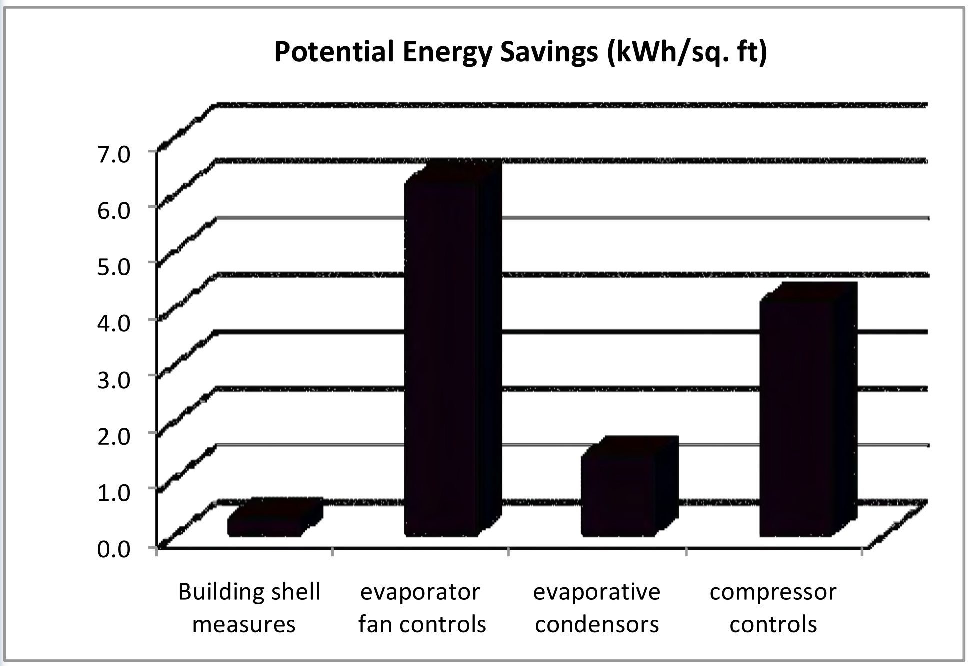
It is recommended to complete annual or semi-annual maintenance in order to maintain the efficiency and increase the longevity of refrigeration equipment. A refrigeration professional will often have the required equipment, such as appropriate lubricants and metering devices, to perform routine maintenance. Refrigeration maintenance includes cleaning condenser coils (possibly pressure cleaning and degreasing), cleaning condensate lines, checking gaskets, wiring, refrigerant levels, monitoring thermostat operation and temperature cycling, and checking defrosting mechanisms.

Heat recovery for space heating is recommended at facilities that use warehouse-size refrigeration and have space heating needs. Heat can be recovered from the condenser units and cycled to in-floor heating systems or through heat exchangers into forced air heating systems.

Description of Best Practice

The energy savings and offset of electrical production achieved by implementing high efficiency refrigeration and/or heat recovery will result in a reduction of greenhouse gas (GHG) emissions, reducing the environmental footprint of the farm.

The table below illustrates the relative potential of energy savings for several common measures from a sample facility. [4]



The savings potential for each individual measure depends strongly upon the length (months) of storage and the condition of the existing equipment and building shell. An energy audit is advised to determine actual savings and a quoted price for any upgrades should be obtained to determine a payback for installing an energy efficiency measure.

Best Practices – High Efficiency Refrigeration

Best Practice

Cost-effectiveness for different efficiency measures is best illustrated with a simple example of a typical operation in Massachusetts. Consider a sample cold storage facility with the following characteristics:

- 1,500 square feet; 6-inches of spray foam insulation throughout
- Used 8 months per year (September-April) for refrigerated (non-CA) storage; storage temperature of 34°F; accessed frequently
- Two (2) 10+ year old standard reciprocating compressor units, each 3.0 HP
- Two (2) 10+ year old evaporators each with a 1/3 HP single pole motor
- No efficiency upgrades have been made

Description of Best Practice

For this sample facility, a number of efficiency measures could be implemented. The table below illustrates approximate project costs, energy savings, and simple payback (without incentives) for several common measures[5]:

Efficiency Measure	Cost Savings	Project Cost	Simple Payback (years)
Replace Evaporator Fan Motor with ECM Motor (Electronically Commutated Motor)	$221	$245	1.1
Floating Head Pressure Controls	$393	$734	1.9
Install Scroll Compressors upon failure of existing compressors	$389	$996 (Incremental cost)	2.6
Outside Air Economizer	$926	$3,500	3.8
Evaporator Fan Motor Controls	$301	$2,254	7.5

As discussed above, the cost-effectiveness of various refrigeration measures is strongly dependent upon the length of storage, and condition and level of control over the existing refrigeration equipment. There are likely to be a number of cost-effective efficiency improvements for old and poorly maintained refrigeration equipment that is used more than six months per year.

For additional approximations of the cost-effectiveness of various energy efficiency measures, refer to the Codes and Standards Enhancement Initiative (CASE) completed in 2008 for the California Energy Commission for energy efficiency standards for refrigerated warehouses.[6]

Best Practices - Lighting

Best Practice

Lighting for Farm Stands, Packing Houses, and Storage Areas

At a Glance:

- Recommended lighting upgrades can use 40-80% less energy
- New lamp types offer better quality light, longer lamp life, and lower operating costs
- Be sure to dispose of bulbs properly, visit: epa.gov/bulbrecycling

Description of Best Practices

Individual Edison Style Light Bulbs

Used for over 100 years, the old Edison style incandescent light bulbs are very inefficient, converting only 5-10% of the used energy to light. The rest is wasted as heat. They also have a short life span (600-2,000 hours). It is recommended to replace these with Energy Star certified compact fluorescent lamps (CFLs). CFLs are an easy and direct replacement for incandescent bulbs. They use 75% less energy and have a life span of 6,000-10,000 hours (6-10 times longer). The following chart can be used to determine a CFL that will provide the same amount of light as an incandescent[7]:

INCANDESCENT BULB (WATTS)	CFL (WATTS)	LIGHT OUTPUT IN LUMENS	ENERGY SAVINGS (LAMPLIFE)
40	13	490-510	$17
60	15	870-950	$33
75	20	1190-1300	$42
100	23-27	1500-1690	$62
120	26-30	1750-1920	$67
150	32-40	2050-2600	$70
200	45	2700	$94
240	55	3600	$114
300	68	4200	$117

Energy Star-certified models come with a two-year warranty, have a minimum rated lifespan of at least 6,000 hours, and cannot emit an audible noise (which can be common with cheaper CFLs). Also, it is important to note that CFLs come with various temperature ratings so it is important to look on the box before purchasing. They are typically rated for either 32°F or 0°F. CFLs operating near their rated temperature may take a few minutes to warm up to get to full output.

Best Practices - Lighting

Best Practice

Source: www.ushio.com

Cold cathode fluorescent lamps (CCFLs) are also an option for cases where either a dimmable light is necessary or where an extremely long lamp life is important (rated for 25,000 hours). They are ideal for applications where reduced maintenance and energy costs are desired (especially in hard to reach lighting installations).

Fluorescent lamps come in a range of colors, measured on the Kelvin scale. Use the following as a reference guide to pick the right color:

Warm white, soft white		Cool White, bright white		Natural or daylight	
Standard color of incandescents bulbs		Good for workspaces		Good for reading	
2700K	3000K	3500K	4100K	5000K	6500K

Description of Best Practices

Replace Halogen Light Fixtures

Source: www.ruralenergy.wisc.edu

The tungsten-halogen lamp (a type of incandescent lamp) is 15% more efficient than a standard incandescent lamp, but still very inefficient compared to other available lighting. Halogen lamps can range from low wattage all the way up to 1500 watts, and they can be replaced with any of the following depending on the application: CFL, HPT8, pulse start metal halide (PSMH), or a high pressure sodium lamp. Any of these light fixtures will reduce energy usage by 60-75% compared to a halogen light.

Low Bay Lighting (< 12 ft)

The most common type of light found with ceilings lower than 12 feet in places such as packing houses, storage areas, shops, potting areas, retail spaces, and coolers are linear fluorescent tubes. They come in two lengths (4' & 8') and in different diameters, measured in eighths of an inch. The old standard, found in facilities that have not updated their lighting in the past 5-10 years is the T12 (1.5 inches in diameter) and use magnetic ballasts.

The best practice for low bay lighting is to install CEE certified HPT8 light fixtures. It is the most efficient and cost feasible lighting application for low ceiling facilities. The Consortium for Energy Efficiency (CEE) is a nonprofit public benefits corporation that promotes the manufacture and purchase of energy efficient lighting. They provide a listing of certified HPT8 lamps and ballasts for 4-foot, 32-watt T8 lighting systems and reduced-wattage T8 systems. State programs such as MassSAVE, implemented through the public utilities, require that new HPT8 systems be certified by CEE in order to receive incentives. Be sure to check with your electric utility provider to determine if you are eligible for any incentives.

Best Practices - Lighting

Best Practice

New linear fluorescent fixtures with electronic ballasts have many benefits over the older magnetic ballasts:

- Increased lamp-ballast efficacy (lumens/watt), meaning more light for less energy
- High frequency AC operation eliminates the flicker associated with magnetic ballast when ambient air temperatures are cooler
- Quieter operation
- Lamps and ballasts are directly interchangeable with magnetic ballasts

Description of Best Practices

High Bay Lighting (>12 ft)

In facilities with mounting heights greater than 12 feet, the most common type of high bay lighting is the probe start 400 watt metal halide. The best practice is to install pulse start metal halide (PSMH) or high ceiling fluorescents such as 3- to 6-lamp CEE certified HPT8 fixtures. The 320 watt PSMH is a common direct replacement for the 400 watt metal halide and will use 25% less energy, have a slightly greater light output, faster warm up/restrike, longer lamp life, up to 50% less light depreciation, and have less color variation.

When deciding between PSMH and HPT8, work with an expert to consider up-front costs, maintenance, and lighting goals. Be careful about installing T5HO (high output) light fixtures with more than four bulbs for high bay lighting due to issues relating to heat buildup in enclosed fixtures. It is recommended to inquire with the manufacturer about whether the fixture has been temperature tested and rated for the conditions it will be placed in (cold to hot climates) and ensure the warranty will be honored for the given conditions.

Cold Storage Lighting

For cold storage, consider LED lighting. LED lights are continually improving with increased research and development. Lights should be third party tested and/or be IES LM-79 and LM-80 certified. LED lights such as the Hubbell Koolbay™ LED Freezer Luminaire offer many benefits[8]:

- Rated for -13°F to 77°F
- Use one third of the energy of a typical HID fixture (150 watts versus 400)
- Has a low BTU output (saving energy on refrigeration costs)
- Low light depreciation (5% at 50,000 hours)
- Instant on (can be used with a photosensor)
- Long life (rated for 60,000 hours) means less maintenance

Outdoor Lighting

Incandescent floodlights and mercury vapor lamps are common in older outdoor lighting and are very inefficient. It is recommended to replace with high pressure sodium (HPS) lamps. HPS lamps have a high efficacy of about 95 [lumens/watt] compared to 15-20 [lumens/watt] for incandescent floodlights, and 50-55 [lumens/watt] for mercury vapor lamps, using 80% and 40% less energy respectively. They emit a yellow-orange light and are generally used for outdoor lighting where color differentiation is not important. They require 3 to 5 minutes to warm up, so may not be applicable for instant-on lighting applications.

Best Practices - Lighting

Best Practice

In typical yard lights about 30% or more of the light goes sideways or up, meaning it is not being used. Consider a full cut-off parabolic reflector such as the Hubbell Skycap to increase the amount of light that reaches the ground (by up to 50%). Using more of the light means it might be possible to use a lower wattage lamp and maintain the same level of illumination.

Lighting upgrades are applicable in most cases. Cost-effective upgrades may be more limited if lights have minimal use over the year.

Description of Best Practices

Install in accordance with national best practices in lighting design such as IESNA recommended practices as well as lighting power densities prescribed by local and state building codes. Follow all local electrical codes.

In areas where fixtures need protection from hazardous parts or from water (including humid locations), install enclosed fixtures with an appropriate Ingress Protection (IP) rating. For more information about the ratings, please refer to: http://en.wikipedia.org/wiki/IP_Code.

Choose HPT8 lamps and ballasts that are CEE certified. It is recommended to choose a high lumen and long life lamp with minimum initial lumens of 3,100 and a rated life of 24,000 hours.

If considering LEDs, it is recommended to purchase fixtures that meet the IESNA LM-79 and LM-80 standards. This is a third-party test that will ensure the LED operates as stated. To verify marketing claims, visit the U.S. Department of Energy – sponsored Lighting Facts website, which reports independent LED testing results: www.lightingfacts.com.

Be sure to verify the temperature and humidity rating of the light fixture to ensure it will work as designed in the given environment.

Light levels gradually change as they age. Be sure to change lamps as recommended per the manufacturer to ensure adequate light levels are maintained as designed.

Be sure to properly recycle all bulbs as required, including all fluorescent and high intensity discharge (HID) lamps such as metal halides and high pressure sodium (HPS). For more information about proper recycling, visit: www.epa.gov/bulbrecycling.

Best Practices - Lighting

Best Practice

When compared to a T12 system, electricity savings of a HPT8 system can be as high as 40 percent. Lighting systems meeting the CEE specifications are generally 10-20 percent more efficient than standard T8 systems.

Energy savings of a fixture can be calculated by the following equation:

$$Annual\ Energy\ Savings\ [kWh] = \left[\frac{old\ [watts] - new[watts]}{1000}\right] x\ daily\ hours\ of\ use\ x\ 365\ days$$

Please Note: The quantity and quality of lighting can vary greatly. For a more detailed description of various types of lights and potential energy savings, please refer to the Natural Resources Conservation Service (NRCS) online lighting energy self assessment, located at: www.ruralenergy.wisc.edu.

Description of Best Practices

The energy savings and offset of electrical production achieved by implementing energy efficient lighting will result in a reduction of greenhouse gas (GHG) emissions. Reducing energy use reduces the overall GHG footprint of the farm by minimizing the amount of emissions released from fossil fuel power plants.

The actual savings of installing new light can vary greatly depending on factors such as installed costs and annual hours of use. To determine a simple payback, take the installed cost and divide by the annual energy savings as determined from the above equation or the online calculator from NRCS.

New light fixtures that contain bulbs with a longer rated life can provide additional savings by decreasing maintenance and labor costs.

It is usually recommended to replace light fixtures when the simple payback is less than 5-7 years. Some typical costs for various fixtures are:

Light/Fixture	Cost*
23 watt CFL	$4
Retro, (2) 4’ HPT8 lamps, (1) EB	$65
2-lamp, 4' HPT8	$120
4-lamp, 4' HPT8	$140
6-lamp, 4' HPT8	$240
320 PSMH	$240
400 watt HPS	$200
1000 watt HPS	$350

*Costs will vary by type of enclosure, manufacturer, installation costs, as well as other factors and should be confirmed if considering a lighting upgrade. Be sure to check the cold rating for bulbs that may be in areas that are not heated

Funding Opportunities for Massachusetts Farm Energy Projects: Efficiency & Renewables

Where to Start – Information & Resources

Massachusetts Farm Energy Program (MFEP)
MFEP provides technical assistance and funding referrals for farmers looking for financial resources to support energy efficiency or renewables projects. MFEP staff are up-to-date on the evolving funding opportunities and offer an initial one-stop shop for funding resources for farm energy projects. Contact MFEP staff at (413) 256-1607.

Farm Energy Discount Program
All **agricultural ratepayers** in Massachusetts enjoy a **mandated 10% reduction on their energy bills** for electricity and natural gas supplied by public utilities as a result of legislation enacted to restructure the utility industry. Individual and corporations that are “principally and substantially engaged in the business of production agriculture or farming for an ultimate commercial purpose” are eligible. The Massachusetts Department of Agricultural Resources (MDAR) is the state agency responsible for determining farm eligibility for the Farm Energy Discount. A two-page application is available at http://www.mass.gov/agr/admin/farmenergy.htm or contact Linda Demirjian, Office Manager, MDAR, at (6l7) 626-1733.

Massachusetts Department of Agricultural Resources (MDAR)
MDAR offers **energy related grant opportunities** through the Ag-Energy Grant Program in May-June each year, in addition to farm viability and business development grants that may consider energy projects as a component.

MDAR also offers **support for farms** interested in energy efficiency, conservation, and renewables through their renewable energy coordinator position. More information and technical resources are available at http://www.mass.gov/agr/programs/energy/index.htm. To discuss the technical aspects of proposed energy projects, contact Gerry Palano, MDAR Renewable Energy Coordinator at 617-626-1706 or Gerald.Palano@state.ma.us.

DSIRE - Database of State Incentives for Renewables and Efficiency
This online database provides up-to-date resources on financial incentives for renewables and efficiency projects from state and federal sources, many of which are applicable to farm businesses. Search the Massachusetts pages for more information at www.dsireusa.org.
Installers and Contractors
Independent equipment installers, dealers, and contractors are a good source of information related to financial incentives for energy projects. Particularly in the case of renewable energy, installers need to track funding programs and realistically estimate how they affect the payback period for the project in order to maintain a competitive advantage in their field.

Energy Efficiency Financial Resources

State Resources

Public Utility Energy Efficiency Programs
Customers of investor-owned ("public") utility companies pay into conservation, efficiency, and renewable energy funds and therefore have access to energy efficiency programs. These "public" energy conservation programs are regulated by the MA Department of Public Utilities. Typically utilities offer **energy assessments**, performed by employees or contractors, as well as **financial incentives** (cost-share) on cost-effective energy efficiency measures.

There are four investor-owned electric utility companies in Massachusetts: National Grid, NSTAR, UNITIL (Fitchburg Gas & Electric), and Western Massachusetts Electric Company. In addition, Cape Light Compact operates the regional energy efficiency program for the Cape and islands. Natural gas companies include Berkshire Gas, Columbia Gas of Massachusetts (formerly Bay State Gas), National Grid (formerly Keyspan Gas), and NSTAR. For contact information related to farm energy assessments and incentives, go to http://www.berkshirepioneerrcd.org/mfep/existing.php or call the Massachusetts Farm Energy Program.

Municipal Utilities
Customers that are serviced by the 40 municipal electric and gas utility departments in the state typically do not pay into conservation or renewable energy funds. Some municipal utility companies have developed fee for service audit programs. Contact your individual municipal utility company to see what programs are available.

Federal Resources

USDA-Rural Development's (RD) Section 9007: Rural Energy for America Program (REAP)
USDA-Rural Development administers competitive grants for energy efficiency and renewable energy projects at 25% of eligible project costs, as well as guaranteed loans, to farmers and rural small businesses. The Massachusetts Farm Energy Program offers informational sessions and grant writing assistance to farmers for applying to this program, in cooperation with Berkshire-Pioneer RC&D, the Massachusetts Woodlands Institute, and USDA-Rural Development. The annual application deadline is generally in the spring. For information, go tohttp://www.rurdev.usda.gov/rbs/farmbill/index.html or contact your local USDA-Rural Development Area Office.

Energy efficiency project applications to REAP require an energy assessment or audit, and renewable projects require technical reports from installers. MFEP offers technical and financial assistance for energy audits but farmers must apply for an audit prior to the REAP application announcement. In addition, MFEP strongly encourages producers to work on preparing the application during slower seasons on the farm.

USDA-Environmental Quality Incentives Program (EQIP)
Under the 2008 Food, Conservation and Energy Act the Natural Resources Conservation Service (NRCS) can provide eligible producers with program support through the Environmental Quality Incentives Program (EQIP) to implement cost-effective and innovative practices that improve air quality. Individuals, groups and entities who own or manage farmland, pastureland or non-industrial forest land are eligible to apply. Producers with an annual minimum of $1,000 of agricultural products produced and/or sold from their operation are eligible to apply. For 2009 EQIP provided funding for specific conservation practices related to anaerobic digestion, greenhouse energy screens and horizontal air flow, and cranberry auto-start systems. More information about EQIP can be found at: http://www.ma.nrcs.usda.gov/programs/airquality/index.html or contact your local NRCS office.

Renewable Energy Financial Resources

State Resources

Department of Public Utilities (DPU) Net Metering
Net metering for wind, solar and agricultural energy installations encourages public utility customers to install solar panels and wind turbines, by allowing them to earn credit on their electric bills if they generate more power than they need. Farms are also encouraged to install additional renewable technologies such as anaerobic digesters.) Under the Green Communities Act signed by Governor Patrick in 2008, utility companies must compensate their customers for up to 2 megawatts of excess electricity at the retail rate rather than the lower wholesale rate. Additionally, customers may allocate their credits to other customers. To find out how you can apply for net metering contact your local eligible utility (NGRID, NSTAR, WMECO or UNITIL), or work through your renewable energy installer.

Municipal utility customers planning to install a renewable energy project to produce electricity will need to contact their suppliers to review net metering and interconnection policies.

Massachusetts Clean Energy Center (MassCEC)
The Green Jobs Act of 2008 created the Massachusetts Clean Energy Center (MassCEC) to accelerate job growth and economic development in the state's clean energy industry. The Renewable Energy Generation division of MassCEC is responsible for supporting renewable energy projects throughout the Commonwealth.

MassCEC has awarded funds to hundreds of businesses, towns, and non-profits for feasibility and/or design and construction of solar panels, wind turbines, biomass systems, hydroelectric systems, and other clean energy systems. Contact MassCEC to learn about current programs like Commonwealth Wind and Commonwealth Solar at www.masscec.com or call (617)315-9355.

Renewable Energy Certificates (RECs)
RECs are a means by which the environmental benefits, also known as the renewable attributes, of energy production by eligible renewable energy technologies can be sold to retail electric suppliers (RES) who are required to buy a minimum amount of these attributes to meet Massachusetts' renewable portfolio standard (RPS) requirements. For more details regarding eligible technologies and how prices are determined, refer to the MA Department of Energy Resources (DOER).

Solar Renewable Energy Certificates (SRECs)
The SRECs program is a market-based incentive program to support the development of 400 MW of solar photovoltaic (PV) infrastructure across the Commonwealth. SRECs are a means by which solar energy producers can sell the environmental attributes of solar generation to public utilities which are required to buy a minimum amount to meet Massachusetts' renewables portfolio standard (RPS) requirements. The sale of these certificates allows for a consistent cash flow for a ten-year period.

State Resources (cont.)

Massachusetts State Tax Deduction
Businesses in Massachusetts may deduct from net income, for state excise tax purposes, the installed cost of renewable energy systems. See www.dsireusa.org or contact a tax consultant for more details.

Federal Resources

USDA-Rural Development's (RD) Section 9007: Rural Energy for America Program (REAP)
The Section 9007 of the 2008 Farm Bill provides funding for renewable energy systems and energy efficiency improvements. USDA-Rural Development administers these funds and offers competitive grants at 25% of eligible project costs, as well as guaranteed loans, to farmers and rural small businesses. The Massachusetts Farm Energy Program offers informational sessions and grant writing assistance to farmers for applying to this program, in cooperation with Berkshire-Pioneer RC&D, the Massachusetts Woodlands Institute, and USDA-Rural Development. The annual application deadline is generally in the spring. For more information, go to http://www.rurdev.usda.gov/rbs/farmbill/index.html, or contact your local USDA-Rural Development Area Office.

Business Investment Tax Credit (ITC) and American Recovery and Reinvestment Act of 2009 (ARRA)
The federal business energy investment tax credit available under 26 USC § 48, and expanded by the Energy Improvement and Extension Act of 2008 (H.R. 1424) in October 2008 and the American Recovery and Reinvestment Act of 2009 in February 2009, provides tax credits for a range of renewable energy projects, ranging from 10%-30% of the eligible costs of renewable energy projects.
Deadlines: Credit Termination Dates vary by technology, but are generally available for eligible systems placed in service before January 1, 2017 (with the exception of large wind 1/1/13 and biomass 1/1/14).

U.S. Department of Treasury Renewable Energy Grants
Instead of taking the energy investment credit (described above), a taxpayer can apply for a cash payment valued at 30% of the total system cost for solar and wind systems through the Department of Treasury (section 1603 Cash Payment). More information is available at http://www.treas.gov/recovery/1603.shtml.
Deadline: construction must begin by 12/31/2011

Federal Accelerated and Bonus Depreciation
Under the federal Modified Accelerated Cost-Recovery System (MACRS), businesses may recover investments in certain property through depreciation.

Next Steps

Reviewing the *Massachusetts Farm Energy Best Management Practices Guide* is the first step in reducing energy use and saving money. Below are some steps to keep in mind for successful energy management.

Steps to Successful Energy Management

1. ***Learn about energy conservation, energy efficiency, and renewable energy***
   Learning about your energy use and ways to reduce it or supplement it with renewable energy is the first step. There is much information available about reducing energy use as well as case studies of farms that have taken action.

2. ***Apply for a farm energy audit or renewable energy assessment***
   An energy audit can help determine where energy is being wasted by inefficient equipment and practices and can recommend solutions. After reading about the MFEP Audits & Incentives Program on the Berkshire Pioneer RC&D website, complete an application to apply for an energy audit or renewable energy assessment. The link to the application is: www.berkshirepioneerrcd.org/mfep/forms/application.php.

3. ***Apply energy conservation practices***
   The easiest and most cost effective method of achieving energy savings is through energy conservation. Energy conservation means using energy wisely and eliminating energy waste, such as running a heater or a ventilation fan when it's not necessary.

4. ***Apply recommended energy efficiency practices***
   Energy efficiency means using less energy to produce the same end result. This manual focuses on conventional energy efficiency measures using current applicable technology. Energy efficiency measures should be taken before considering renewable energy. Reducing the amount of energy used is more cost effective than purchasing renewable energy to power inefficient devices.

5. ***Focus on Time-of-Use management (for cost savings, if applicable)***
   With proper Time-of-Use energy management, it is possible for agricultural producers to reduce their energy bills. Load demands change dramatically throughout the day, but utility companies must have the capacity to provide enough electricity for on-peak demand (typically aligning with summer months and daylight hours). In order to spread out this peak demand more evenly over the 24-hour day, electric utility companies provide a Time-of-Use (TOU) pricing structure. In a TOU billing structure, kWh prices are increased during on-peak hours and are reduced during off-peak hours to encourage customers to change behavior by using energy intensive equipment outside of peak hours.
6. ***Installation of Renewable Energy***
   After the previous steps have been exhausted, renewable energy is the final step. Renewable energy has a much lower environmental impact than conventional sources of energy production and decreases the US dependence on a fossil fuel economy. It also helps stimulate the economy and create job opportunities. Money spent on renewable energy is spent on materials and staff that build and maintain the equipment instead of importing non-renewable fossil fuels. This manual focuses on solar thermal, photovoltaic, wind, and biomass. Other technologies include, but are not limited to, anaerobic waste digesters (biogas), geothermal, and hydro.

Disclaimers

- Mention of trade names and products is for information purposes only and constitutes neither an endorsement of, recommendation of, nor discrimination against similar products not mentioned.
- Although this guide contains research-based information and the contributors have used their best efforts in preparing this guide, the contributors make no warranties, express or implied, with respect to the use of this guide. Users of this guide maintain complete responsibility for the accuracy and appropriate application of this guide for their intended purpose(s).
- In no event shall the contributors be held responsible or liable for any indirect, direct, incidental, or consequential damages or loss of profits or any other commercial damage whatsoever resulting from or related to the use or misuse of this guide.
- The contributors emphasize the importance of consulting experienced and qualified consultants, advisors, and other business professionals to ensure the best results.
- Project costs presented in this report are estimates only, based upon available pricing information at the time of compiling this report. Actual costs will likely vary due to many different variables.

Energy and Fuel Prices

Energy and fuel prices are constantly fluctuating. Actual prices will affect the economic feasibility of a project. The following energy prices have been used for purposes of the calculations throughout this manual:

- $0.15/kWh
- $1.10/therm
- $2/gallon propane (LP)
- $2.5/gallon fuel oil
- $200/full cord of wood (measured as 4' x 4' x 8')

For more information, contact the Mass Farm Energy Program at Berkshire-Pioneer RC&D: www.berkshirepioneerrcd.org/mfep or 413.256.1607

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Massachusetts Farm Energy Program
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